PBL Project 2

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% Code Contributors:
% Anika Kulkarni    Last Commit: 10/21/2025
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% Felix Wang        Last Commit: 10/5/2025

% General Housekeeping:
% ! Use Tabs for Indents

% Overview
% -----------------------------
% ACCOUNTING EQUATION: Ψ_out = Ψ_in [1 - w_reabs + w_sec]
% <https://ibb.co/356L4rWn>
% Assuming s-s, no rxn

% END GOAL: line plot of flow rates of each component per nephronal unit
% Nephronal unit = pseudomeasure of time

% LIMITATIONS:
% (1) Water flow held constant (no ADH modulation)
% (2) Active/passive transport not explicitly modeled
% (3) Tubuloglomerular feedback not included

function[molar_flow_rates, concs] = kidney_model(C0, snGFR, condition)

% Indices
% -----------------------------
% Chemical Constituents
chemicals = ["Na+", "Cl-", "Urea", "Glucose", "K+", "HCO3-", "Mg2+", "PO4
3-", "Creatinine", "Ca2+"];
molec_weights = [22.989, 35.453, 60.056, 180.156, 39.098, 61.020, 24.305,
94.971, 113.12, 40.08]; % For gram conversion; in g/mol

% Nephronal Units
units = ["RC", "PT, S1", "PT, S2", "PT, S3", "DL", "AL", "DT", "CD"];
% RC = Renal Corpuscle
% PT = Proximal Tubule, split into S1, S2, and S3
% DL = Descending Limb
% AL = Ascending Limb
% DT = Distal Tubule
% CD = Collecting Duct
% Corresponds to x-axis for plots

nSeg = length(units);
nSol = length(chemicals);

% Data Matrices
% -----------------------------
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% Fractions derived from a host of literature sources, primarily:
% - Weinstein, A. M. Seldin and Giebisch's The Kidney. Elsevier Inc., 2008.
849-887.1081-1142
% - Vallon, V. Am J Physiol Cell Physiol. 2011 Jan; 300(1): C6-C8.
% - Oregon State University, open courseware

%{
      Na+     Cl-    Urea    Gluc     K+     HCO3-   Mg2+    PO43-
Creat    Ca2+
RC | (1,1) | (1,2) | (1,3) | (1,4) | (1,5) | (1,6) | (1,7) | (1,8) | (1,9) |
(1,10)
S1 | (2,1) | (2,2) | (2,3) | (2,4) | (2,5) | (2,6) | (2,7) | (2,8) | (2,9) |
(2,10)
S2 | (3,1) | (3,2) | (3,3) | (3,4) | (3,5) | (3,6) | (3,7) | (3,8) | (3,9) |
(3,10)
S3 | (4,1) | (4,2) | (4,3) | (4,4) | (4,5) | (4,6) | (4,7) | (4,8) | (4,9) |
(4,10)
DL | (5,1) | (5,2) | (5,3) | (5,4) | (5,5) | (5,6) | (5,7) | (5,8) | (5,9) |
(5,10)
AL | (6,1) | (6,2) | (6,3) | (6,4) | (6,5) | (6,6) | (6,7) | (6,8) | (6,9) |
(6,10)
DT | (7,1) | (7,2) | (7,3) | (7,4) | (7,5) | (7,6) | (7,7) | (7,8) | (7,9) |
(7,10)
CD | (8,1) | (8,2) | (8,3) | (8,4) | (8,5) | (8,6) | (8,7) | (8,8) | (8,9) |
(8,10)
%}

% Reabsorption fractions per constituent (of incoming stream) per unit
% This is what's returned to interstitial fluid
% Solutes    Na+,     Cl-,     Urea,    Glucose, K+,      HCO3-,   Mg2+,
PO43-,   Creat,   Ca2+
reabs_frac = [0,       0,       0,       0,       0,       0,       0,
0,       0,       0;    % RC
    0.33,    0.33,    0,       0.90,    0,       0.80,    0,       0.35,
0,       0.35; % PT, S1
    0.328,   0.328,   0,       0.09,    0,       0.10,    0,       0.25,
0,       0.25; % PT, S2
    0.222,   0.222,   0.50,    0,       0.60,    0,       0.20,    0.10,
0,       0.10; % PT, S3
    0,       0,       0,       0,       0,       0.15,    0,       0,
0,       0;    % DL (salt-impermeable)
    0.25,    0.25,    0,       0,       0.25,    0,       0.7,     0,
0,       0.20; % AL (water-impermeable, salt-permeable)
    0.05,    0.05,    0,       0,       0,       0.05,    0.05,    0.05,
0,       0.10; % DT
    0,       0,       0,       0,       0,       0,       0,       0,
0,       0.05; % CD
    ];
% Note that Na/Cl reabsorption can increase to 0.02/0.03 when producing
dilute urine (over-hydration); also when high salt intake (need to dilute
urine)
% Note that urea is reabsorbed when producing concentrated urine to conserve
water, as urea establishes an osmotic gradient (de-hydration)
% However, because this is tightly regulated by ADH and other hormones, this
```

```
is outside the scope of this model
reabs_frac = max(0, min(reabs_frac, 0.999)); % Safety clamp

% Secretion fractions per constituent (of incoming stream) per unit
% This is what's secreted by bloodstream into tubule post-RC (initial
filtration)
% Solutes    Na+,     Cl-,     Urea,    Glucose, K+,      HCO3-,   Mg2+,
PO43-,   Creat,   Ca2+
sec_frac =   [0,       0,       0,       0,       0,       0,       0,
0,       0,       0; % RC
    0,       0,       0,       0,       0,       0,       0,       0,
0,       0; % PT, S1
    0,       0,       0,       0,       0,       0,       0,       0,
0.30,    0; % PT, S2
    0,       0,       0,       0,       0,       0,       0,       0,
0,       0; % PT, S3
    0,       0,       0.15,    0,       0,       0,       0,       0,
0,       0; % DL (salt-impermeable)
    0,       0,       0,       0,       0,       0,       0,       0,
0,       0; % AL (water-impermeable, salt-permeable)
    0,       0,       0,       0,       0.10,    0,       0,       0,
0,       0; % DT
    0,       0,       0,       0,       0.10,    0,       0,       0,
0,       0; % CD
    ];
sec_frac = max(0, min(sec_frac, 0.999)); % Safety clamp

% Molar flow rates per constituent per unit
% To be solved for; preallocated for now
molar_flow_rates = zeros(nSeg,nSol);

% Concentrations per constituent per unit
% To be solved for; preallocated for now
concs = zeros(nSeg,nSol); % mmol/L

% Volumetric flow rates per constituent per unit
vol_flow_rates = snGFR * ones(nSeg,1); % mL/min
% Set up so molar flow rate = vol flow rate * conc, so mL/min * mM * 1
L/1000 mL = mmol/min

% Calculations
% -----------------------------
% Initialize input stream to first unit (RC)
concs(1,:) = C0; % mmol/L, aka mM; TAKEN AS INPUT
molar_flow_rates(1,:) = snGFR .* concs(1,:) * 1e-3; % mmol/min; snGFR TAKEN
AS INPUT

% Conditional
% -----------------------------
% Adjust reabsorption fractions for salt in the case of high salt intake -
whether a one-off event or hypernatremia/hyperchloremia
if concs(1, 1) > 140.0000 && concs(1, 2) > 106
      sec_frac(8,1) = 0.02;  % Na+
      sec_frac(8,2) = 0.03;  % Cl-
```

```
end

% Math Propagation
% -----------------------------
% Propagate flow rates by unit/segment
for i = 2:nSeg

    % Accounting for each chemical constituent
    N_in  = molar_flow_rates(i-1,:); % Vector with inflows for all chemicals
(mmol/min)
    N_out = N_in .* (1 - reabs_frac(i,:) + sec_frac(i,:)); % Vector with
outflows for all chemicals

    if any(N_out < 0)
        errordlg("Negative Flow Rate at Row " + i + "!!!")
    end

    % Fill row i of 8x10 matrix
    molar_flow_rates(i,:) = N_out; % Given that P_out is a vector containing
flow rates of all chemicals at that unit
    concs(i,:) = molar_flow_rates(i,:) ./ vol_flow_rates(i); % mmol/min /
mL/min = mmol/L
end

% Outlets in grams/min
grams_per_min_out = zeros(1,nSol);
for j = 1:nSol
    grams_per_min_out(j) = molar_flow_rates(end,j) * molec_weights(j) *
1e-3; % mmol/min * g/mol * 1e-3 = g/min
end

disp("Outlet (collecting duct) in grams/min per solute: ");
for k = 1:nSol
    disp(chemicals(k) + ":" + num2str(grams_per_min_out(k)));
end

% Graphs
% -----------------------------
% Display to check matrix is reasonable
disp('8x10 Molar Flow Rate Matrix (rows = RC, S1, S2, S3, DL, AL, DT, CD;
columns = Na+, Cl-, Urea, Glucose, K+, HCO3-, Mg2+, phosphate, creatinine,
Ca2+):');
disp(molar_flow_rates);

colors = ["#012966", "#005f73", "#0a9396", "#94d2bd", "#e9d8a6", ...
          "#ee9b00", "#ca6702", "#bb3e03", "#ae2012", "#9b2226"];

% Figure 1: Concentrations
figure('Units','normalized','Position',[0.05 0.05 0.9 0.8])
tiledlayout(2, 5, 'TileSpacing','compact', 'Padding','compact')

for k = 1:nSol
    nexttile
    plot(1:nSeg, concs(:,k), '-', 'Color', colors(k), 'LineWidth', 2);
```

```
    grid on
    title(chemicals(k) + " Concentration", 'FontWeight','bold', 'FontSize',
12)
    xticks(1:nSeg)
    xticklabels(units)
    ylabel('mM')
    ylim('auto')
end

sgtitle({"Solute Concentrations Along Nephron Segments", "Test Case: " +
condition}, 'FontSize', 14, 'FontWeight','bold')


% Figure 2: Flow Rates
figure('Units','normalized','Position',[0.05 0.05 0.9 0.8])
tiledlayout(2, 5, 'TileSpacing','compact', 'Padding','compact')

for k = 1:nSol
    nexttile
    plot(1:nSeg, molar_flow_rates(:,k), '-', 'Color', colors(k),
'LineWidth', 2);
    grid on
    title(chemicals(k) + " Flow", 'FontWeight','bold', 'FontSize', 12)
    xticks(1:nSeg)
    xticklabels(units)
    ylabel('mmol/min')
    ylim('auto')
end

sgtitle({"Molar Flow Rates Along Nephron Segments", "Test Case: " +
condition}, 'FontSize', 14, 'FontWeight','bold')

end

% Test Cases
% -----------------------------
function[conc_out, snGFR_out] = test_cases(C0, snGFR, condition)
% Implements test cases by adjusting inlet concentrations and single-nephron
GFR accordingly
% condition: 'healthy', 'ckd3b' (CKD, stage 3b), 't2dm_early' (early type 2
% diabetes), 't2dm_late' (late type 2 diabetes), 'htn' (hypertension)

% Re-indexing for convenience
Na = 1;
Cl = 2;
Urea = 3;
Gluc = 4;
K = 5;
HCO3 = 6;
Mg = 7;
PO4 = 8;
Creat = 9;
Ca = 10;
```

```
switch lower(condition)
    case 'healthy'
        % No change, using base values

    case 'ckd3b' % Note that we are modeling stage 3b as this marks
substantial loss of kidney function and sure-fire diagnosis of CKD
        snGFR = snGFR * 37/105; % Using a scaling factor as reference as
snGFR values not available
        % Normal GFR = 90-120 mL/min; Stage 3b GFR = 30-44 mL/min

        % Creatinine level increased by 60%
        % Typical creatinine level: 0.7-1.3 mg/dL in males, 0.6-1.1 mg/dL in
females
        % CKD3b creatinine level: 1.2-2.0 mg/dL in males, 1.8-3.0 mg/dL in
females
        % 50-70% increase
        C0(Creat) = C0(Creat) * 1.6;

        % Urea level increased by 40% (estimate)
        C0(Urea) = C0(Urea) * 1.4;

        % Potassium level increased by 15% (estimate; hyperkalemia)
        C0(K) = C0(K) * 1.15;

        % Phosphate level increased by 25% (estimate; due to degradation of
phosphate secretion)
        C0(PO4) = C0(PO4) * 1.25;

        % Bicarbonate level decreased, not significantly (sign of metabolic
acidosis)
        C0(HCO3) = C0(HCO3) * 0.90;

        % Calcium level decreased, not significantly (sign of hypocalcemia)
        C0(Ca) = C0(Ca) * 0.90;

    case 't2dm_early' % Separating early and late stages because early T2DM
= hyperfiltration
        snGFR = snGFR * 1.125; % Approximating hyperfiltration
        % Normal GFR = 120 mL/min; Early T2DM GFR = 120-150 mL/min, median
at 135 mL/min

        C0(Gluc) = 7; % 7 mmol/L = 126 mg/dL, as an average plasma
concentration of glucose during early hyperglycemia

    case 't2dm_late' % Separating early and late stages because late T2DM =
hypofiltration
        snGFR = snGFR * 22/105; % Approximating hypofiltration
        % Normal GFR = 90-120 mL/min; Late T2DM GFR = 15-29 mL/min, median
at 22 mL/min (correlated with Stage 4-5 CKD)

        C0(Gluc) = 9.7; % 8.3-11.1 mmol/L, as an average plasma
concentration of glucose during late stage hyperglycemia
        C0(K) = C0(K) * 1.30; % Jumps to greater than 6 mmol/L
        C0(PO4) = C0(PO4) * 1.15; % Jumps to greater than 1.5 mmol/L
```

```
        C0(HCO3) = C0(HCO3) * 0.85; % Not a substantial decrease but still
indicative of metabolic acidosis

    case 'htn'
        snGFR = snGFR * 0.90;  % Slight decrease to reflect vascular damage

end

conc_out = C0;
snGFR_out = snGFR;

end

% Inputs
% -----------------------------

% BASELINE INLET CONCENTRATIONS
% Inlet filtrate concentrations at renal corpuscle, as INPUT into main
function
C0 = [140.0000, 102.0000, 5.714, 4.6905, 4.3500, 24.0000, 0.8225, 0.3950,
0.0920, 0.5700]; % Na+, Cl-, Urea, Glucose, K+, HCO3-, Mg2+, PO43-,
Creatinine, Ca2+
% In mmol/L
snGFR = 79 / 1000; % nL/min * 1e-3 = mL/min (filtrate into RC/Bowman's
capsule for a healthy kidney)
% A healthy kidney has a single-nephron GFR of approximately 79 +/- 42
nanoliters per minute (nL/min).

% Healthy
[C0_h, sn_h] = test_cases(C0, snGFR, 'healthy');
kidney_model(C0_h, sn_h, "Healthy");

% CKD3b
[C0_ckd, sn_ckd] = test_cases(C0, snGFR, 'ckd3b');
kidney_model(C0_ckd, sn_ckd, "CKD3b");

% T2DM Early
[C0_dme, sn_dme] = test_cases(C0, snGFR, 't2dm_early');
kidney_model(C0_dme, sn_dme, "T2DM (Early)");

% T2DM Late
[C0_dml, sn_dml] = test_cases(C0, snGFR, 't2dm_late');
kidney_model(C0_dml, sn_dml, "T2DM (Late)");

% Hypertension
[C0_htn, sn_htn] = test_cases(C0, snGFR, 'htn');
kidney_model(C0_htn, sn_htn, "Hypertension");

% Combination of all 3, modeling severe CKD
[C0_tmp,  sn_tmp]  = test_cases(C0,      snGFR, 'ckd3b');
[C0_tmp,  sn_tmp]  = test_cases(C0_tmp,  sn_tmp, 'htn');
[C0_combo, sn_combo] = test_cases(C0_tmp, sn_tmp, 't2dm_late');
kidney_model(C0_combo, sn_combo, "CKD3b + HTN + T2DM (Late)");
```

```
Outlet (collecting duct) in grams/min per solute:
Na+:6.3458e-05
Cl-:7.13e-05
Urea:1.5588e-05
Glucose:6.0749e-06
K+:4.8773e-06
HCO3-:1.6816e-05
Mg2+:3.6008e-07
PO4 3-:1.2353e-06
Creatinine:1.0688e-06
Ca2+:5.4163e-07
8x10 Molar Flow Rate Matrix (rows = RC, S1, S2, S3, DL, AL, DT, CD; columns
= Na+, Cl-, Urea, Glucose, K+, HCO3-, Mg2+, phosphate, creatinine, Ca2+):
  Columns 1 through 7

    0.0111    0.0081    0.0005    0.0004    0.0003    0.0019    0.0001
    0.0074    0.0054    0.0005    0.0000    0.0003    0.0004    0.0001
    0.0050    0.0036    0.0005    0.0000    0.0003    0.0003    0.0001
    0.0039    0.0028    0.0002    0.0000    0.0001    0.0003    0.0001
    0.0039    0.0028    0.0003    0.0000    0.0001    0.0003    0.0001
    0.0029    0.0021    0.0003    0.0000    0.0001    0.0003    0.0000
    0.0028    0.0020    0.0003    0.0000    0.0001    0.0003    0.0000
    0.0028    0.0020    0.0003    0.0000    0.0001    0.0003    0.0000

  Columns 8 through 10

    0.0000    0.0000    0.0000
    0.0000    0.0000    0.0000
    0.0000    0.0000    0.0000
    0.0000    0.0000    0.0000
    0.0000    0.0000    0.0000
    0.0000    0.0000    0.0000
    0.0000    0.0000    0.0000
    0.0000    0.0000    0.0000

Outlet (collecting duct) in grams/min per solute:
Na+:2.2361e-05
Cl-:2.5125e-05
Urea:7.6901e-06
Glucose:2.1407e-06
K+:1.9765e-06
HCO3-:5.3331e-06
Mg2+:1.2688e-07
PO4 3-:5.441e-07
Creatinine:6.026e-07
Ca2+:1.7177e-07
8x10 Molar Flow Rate Matrix (rows = RC, S1, S2, S3, DL, AL, DT, CD; columns
= Na+, Cl-, Urea, Glucose, K+, HCO3-, Mg2+, phosphate, creatinine, Ca2+):
  Columns 1 through 7

    0.0039    0.0028    0.0002    0.0001    0.0001    0.0006    0.0000
    0.0026    0.0019    0.0002    0.0000    0.0001    0.0001    0.0000
    0.0018    0.0013    0.0002    0.0000    0.0001    0.0001    0.0000
    0.0014    0.0010    0.0001    0.0000    0.0001    0.0001    0.0000
```

```
    0.0014    0.0010    0.0001    0.0000    0.0001    0.0001    0.0000
    0.0010    0.0007    0.0001    0.0000    0.0000    0.0001    0.0000
    0.0010    0.0007    0.0001    0.0000    0.0000    0.0001    0.0000
    0.0010    0.0007    0.0001    0.0000    0.0001    0.0001    0.0000

  Columns 8 through 10

    0.0000    0.0000    0.0000
    0.0000    0.0000    0.0000
    0.0000    0.0000    0.0000
    0.0000    0.0000    0.0000
    0.0000    0.0000    0.0000
    0.0000    0.0000    0.0000
    0.0000    0.0000    0.0000
    0.0000    0.0000    0.0000

Outlet (collecting duct) in grams/min per solute:
Na+:7.139e-05
Cl-:8.0212e-05
Urea:1.7537e-05
Glucose:1.0199e-05
K+:5.4869e-06
HCO3-:1.8918e-05
Mg2+:4.0508e-07
PO4 3-:1.3897e-06
Creatinine:1.2024e-06
Ca2+:6.0933e-07
8x10 Molar Flow Rate Matrix (rows = RC, S1, S2, S3, DL, AL, DT, CD; columns
= Na+, Cl-, Urea, Glucose, K+, HCO3-, Mg2+, phosphate, creatinine, Ca2+):
  Columns 1 through 7

    0.0124    0.0091    0.0005    0.0006    0.0004    0.0021    0.0001
    0.0083    0.0061    0.0005    0.0001    0.0004    0.0004    0.0001
    0.0056    0.0041    0.0005    0.0001    0.0004    0.0004    0.0001
    0.0044    0.0032    0.0003    0.0001    0.0002    0.0004    0.0001
    0.0044    0.0032    0.0003    0.0001    0.0002    0.0003    0.0001
    0.0033    0.0024    0.0003    0.0001    0.0001    0.0003    0.0000
    0.0031    0.0023    0.0003    0.0001    0.0001    0.0003    0.0000
    0.0031    0.0023    0.0003    0.0001    0.0001    0.0003    0.0000

  Columns 8 through 10

    0.0000    0.0000    0.0001
    0.0000    0.0000    0.0000
    0.0000    0.0000    0.0000
    0.0000    0.0000    0.0000
    0.0000    0.0000    0.0000
    0.0000    0.0000    0.0000
    0.0000    0.0000    0.0000
    0.0000    0.0000    0.0000

Outlet (collecting duct) in grams/min per solute:
Na+:1.3296e-05
Cl-:1.4939e-05
```

Urea:3.2661e-06
Glucose:2.6322e-06
K+:1.3285e-06
HCO3-:2.9949e-06
Mg2+:7.5444e-08
PO4 3-:2.9764e-07
Creatinine:2.2394e-07
Ca2+:1.1348e-07
8x10 Molar Flow Rate Matrix (rows = RC, S1, S2, S3, DL, AL, DT, CD; columns = Na+, Cl-, Urea, Glucose, K+, HCO3-, Mg2+, phosphate, creatinine, Ca2+):
Columns 1 through 7

0.0023	0.0017	0.0001	0.0002	0.0001	0.0003	0.0000
0.0016	0.0011	0.0001	0.0000	0.0001	0.0001	0.0000
0.0010	0.0008	0.0001	0.0000	0.0001	0.0001	0.0000
0.0008	0.0006	0.0000	0.0000	0.0000	0.0001	0.0000
0.0008	0.0006	0.0001	0.0000	0.0000	0.0001	0.0000
0.0006	0.0004	0.0001	0.0000	0.0000	0.0001	0.0000
0.0006	0.0004	0.0001	0.0000	0.0000	0.0000	0.0000
0.0006	0.0004	0.0001	0.0000	0.0000	0.0000	0.0000

Columns 8 through 10

0.0000	0.0000	0.0000
0.0000	0.0000	0.0000
0.0000	0.0000	0.0000
0.0000	0.0000	0.0000
0.0000	0.0000	0.0000
0.0000	0.0000	0.0000
0.0000	0.0000	0.0000
0.0000	0.0000	0.0000

Outlet (collecting duct) in grams/min per solute:
Na+:5.7112e-05
Cl-:6.417e-05
Urea:1.4029e-05
Glucose:5.4674e-06
K+:4.3896e-06
HCO3-:1.5135e-05
Mg2+:3.2407e-07
PO4 3-:1.1117e-06
Creatinine:9.6192e-07
Ca2+:4.8747e-07
8x10 Molar Flow Rate Matrix (rows = RC, S1, S2, S3, DL, AL, DT, CD; columns = Na+, Cl-, Urea, Glucose, K+, HCO3-, Mg2+, phosphate, creatinine, Ca2+):
Columns 1 through 7

0.0100	0.0073	0.0004	0.0003	0.0003	0.0017	0.0001
0.0067	0.0049	0.0004	0.0000	0.0003	0.0003	0.0001
0.0045	0.0033	0.0004	0.0000	0.0003	0.0003	0.0001
0.0035	0.0025	0.0002	0.0000	0.0001	0.0003	0.0000
0.0035	0.0025	0.0002	0.0000	0.0001	0.0003	0.0000
0.0026	0.0019	0.0002	0.0000	0.0001	0.0003	0.0000
0.0025	0.0018	0.0002	0.0000	0.0001	0.0002	0.0000

```
    0.0025    0.0018    0.0002    0.0000    0.0001    0.0002    0.0000

  Columns 8 through 10

    0.0000    0.0000    0.0000
    0.0000    0.0000    0.0000
    0.0000    0.0000    0.0000
    0.0000    0.0000    0.0000
    0.0000    0.0000    0.0000
    0.0000    0.0000    0.0000
    0.0000    0.0000    0.0000
    0.0000    0.0000    0.0000

Outlet (collecting duct) in grams/min per solute:
Na+:4.2167e-06
Cl-:4.7378e-06
Urea:1.4501e-06
Glucose:8.3479e-07
K+:4.8451e-07
HCO3-:8.5482e-07
Mg2+:2.3927e-08
PO4 3-:1.1799e-07
Creatinine:1.1363e-07
Ca2+:3.2392e-08
8x10 Molar Flow Rate Matrix (rows = RC, S1, S2, S3, DL, AL, DT, CD; columns
= Na+, Cl-, Urea, Glucose, K+, HCO3-, Mg2+, phosphate, creatinine, Ca2+):
   1.0e-03 *

  Columns 1 through 7

    0.7349    0.5354    0.0420    0.0509    0.0341    0.0964    0.0043
    0.4924    0.3587    0.0420    0.0051    0.0341    0.0193    0.0043
    0.3309    0.2411    0.0420    0.0046    0.0341    0.0173    0.0043
    0.2574    0.1876    0.0210    0.0046    0.0137    0.0173    0.0035
    0.2574    0.1876    0.0241    0.0046    0.0137    0.0147    0.0035
    0.1931    0.1407    0.0241    0.0046    0.0102    0.0147    0.0010
    0.1834    0.1336    0.0241    0.0046    0.0113    0.0140    0.0010
    0.1834    0.1336    0.0241    0.0046    0.0124    0.0140    0.0010

  Columns 8 through 10

    0.0030    0.0008    0.0027
    0.0019    0.0008    0.0018
    0.0015    0.0010    0.0013
    0.0013    0.0010    0.0012
    0.0013    0.0010    0.0012
    0.0013    0.0010    0.0009
    0.0012    0.0010    0.0009
    0.0012    0.0010    0.0008
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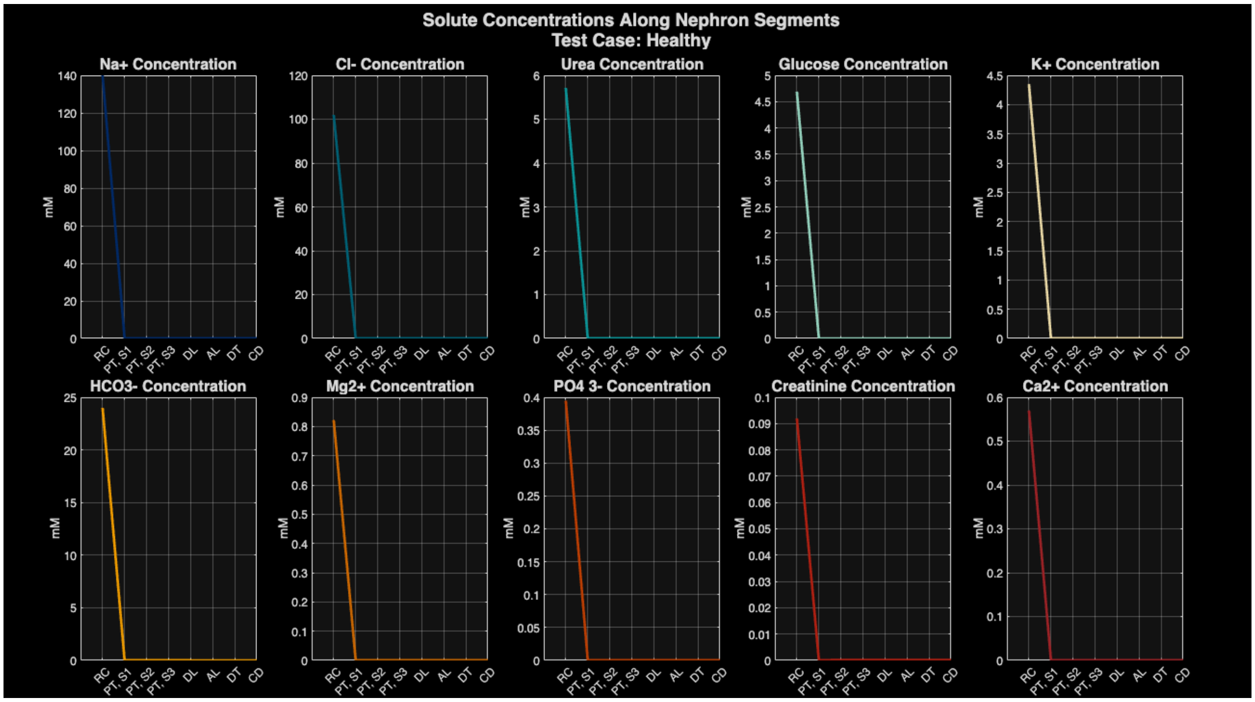
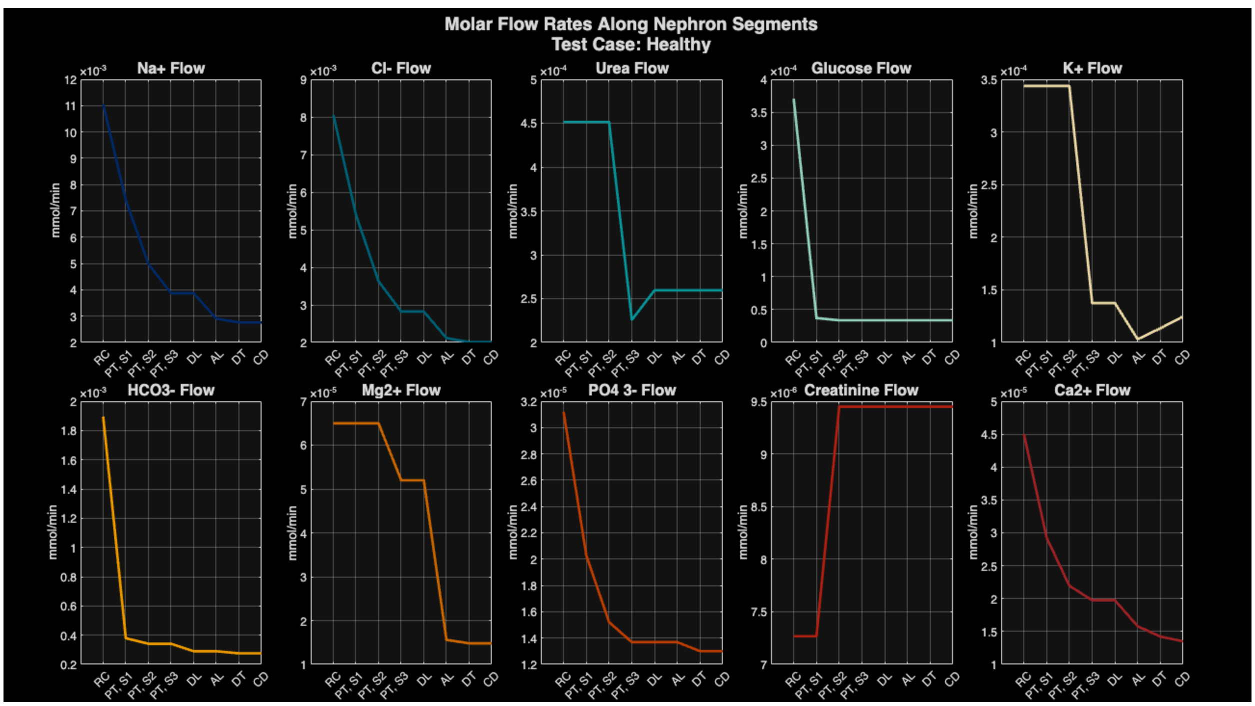
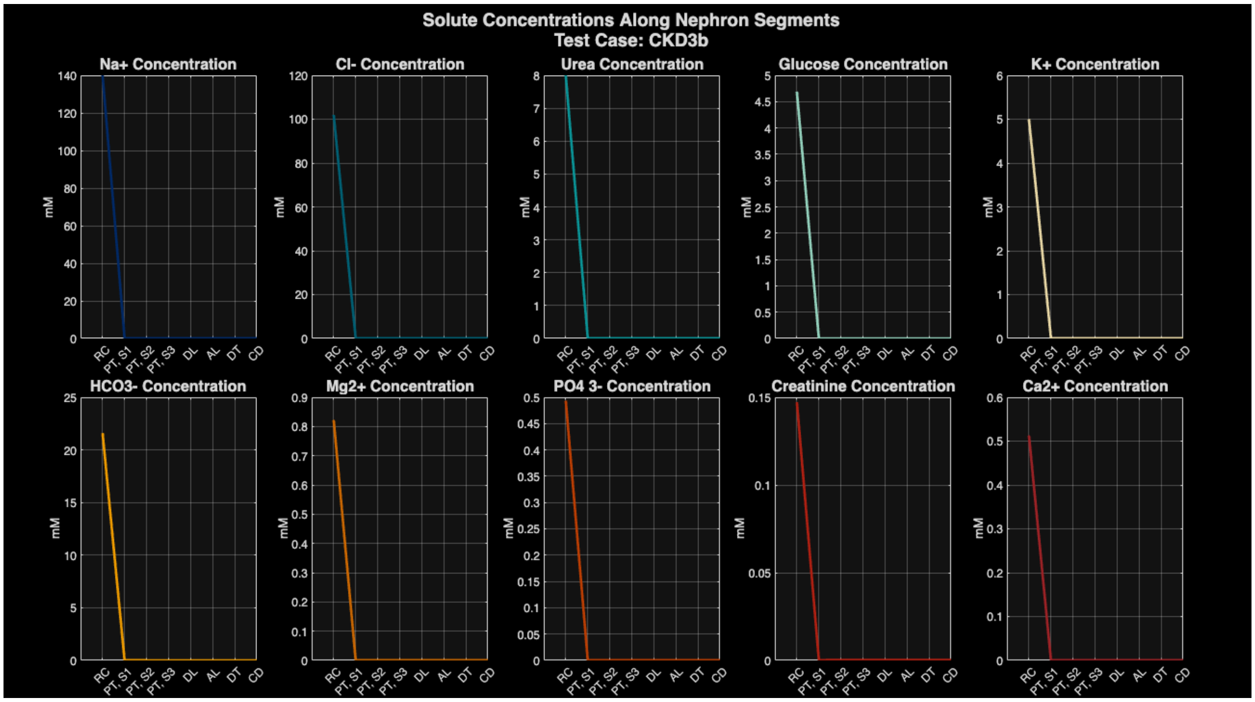
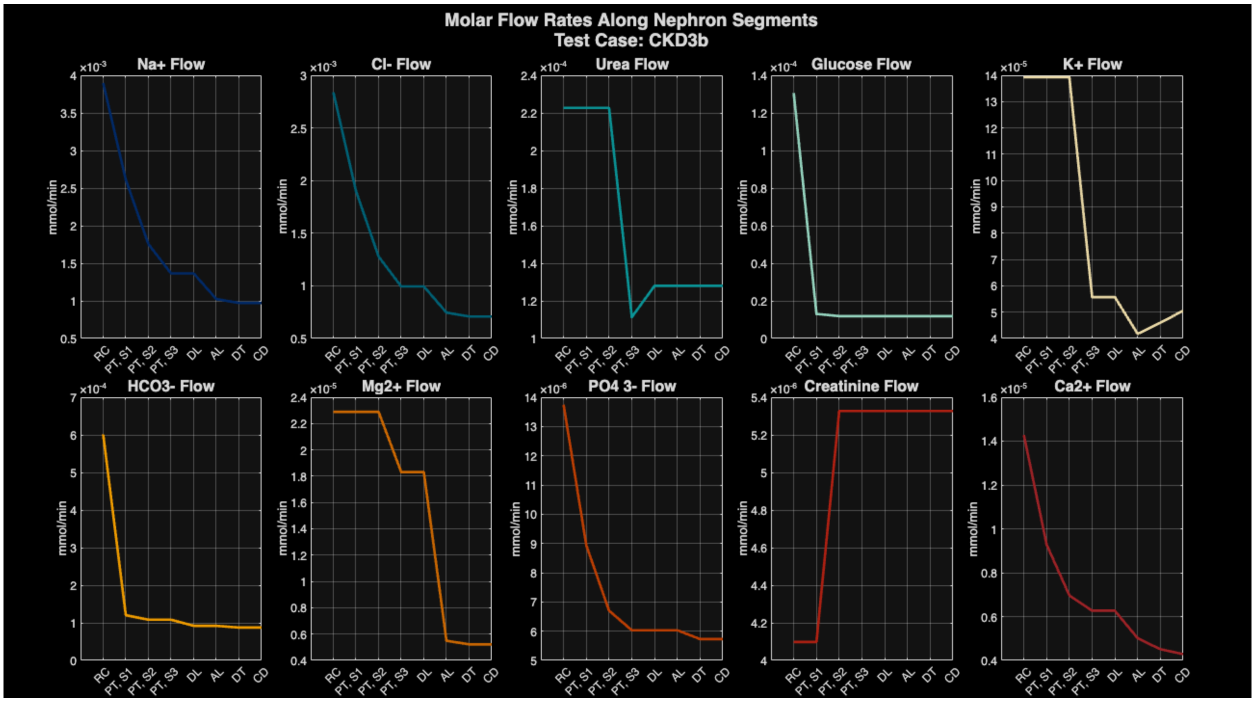
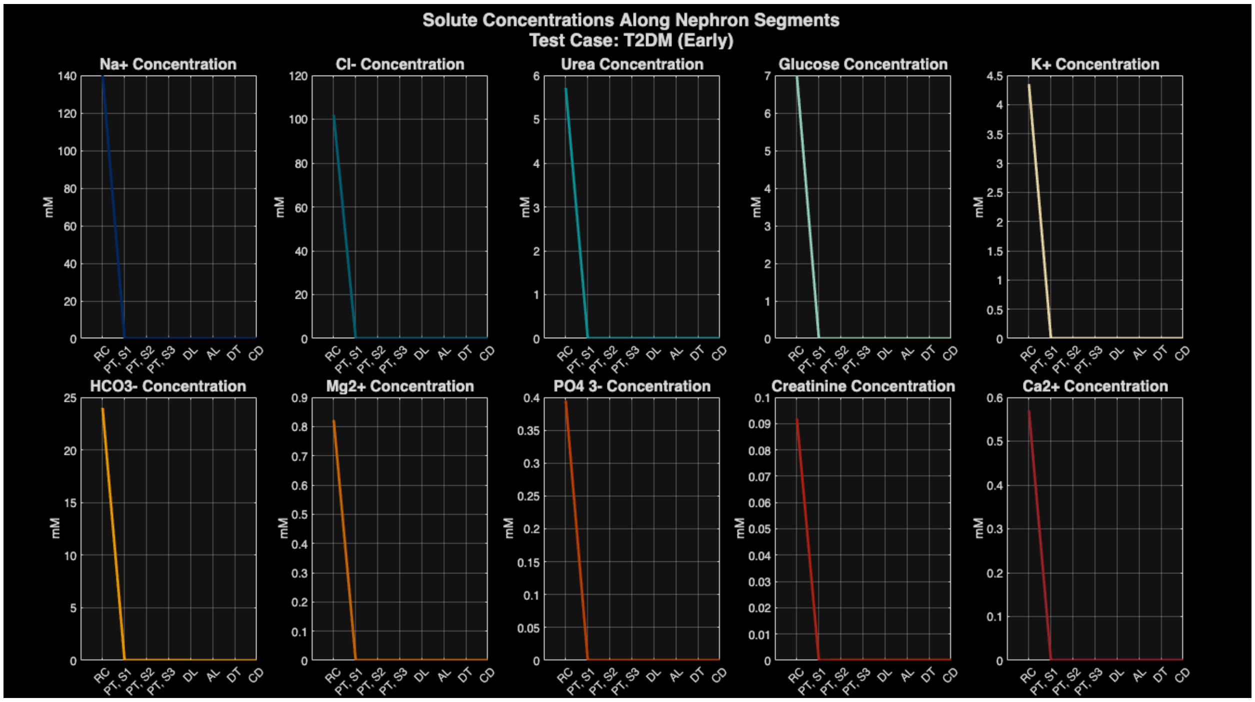
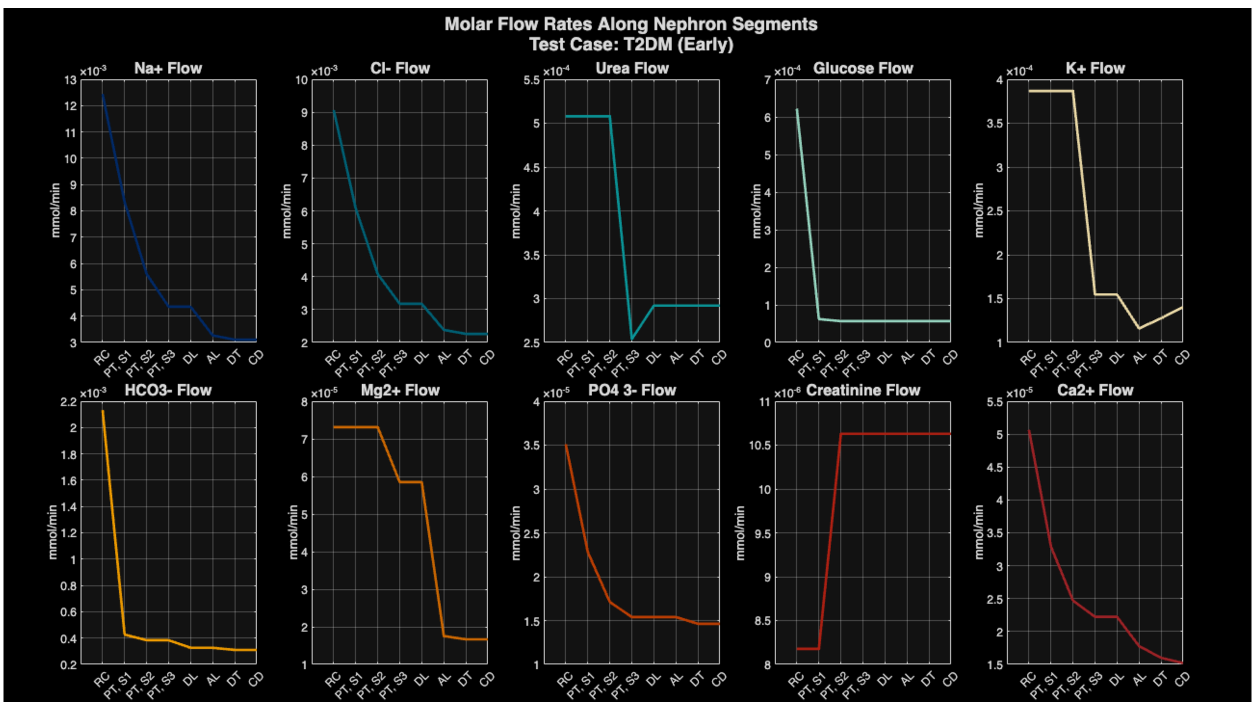

Solute Concentrations Along Nephron Segments
Test Case: Healthy
Na+ Concentration
Cl- Concentration
Urea Concentration
Glucose Concentration
K+ Concentration
HCO3- Concentration
Mg2+ Concentration
PO4 3- Concentration
Creatinine Concentration
Ca2+ Concentration
mM
RC
PT, S1
PT, S2
PT, S3
DL
AL
DT
CD

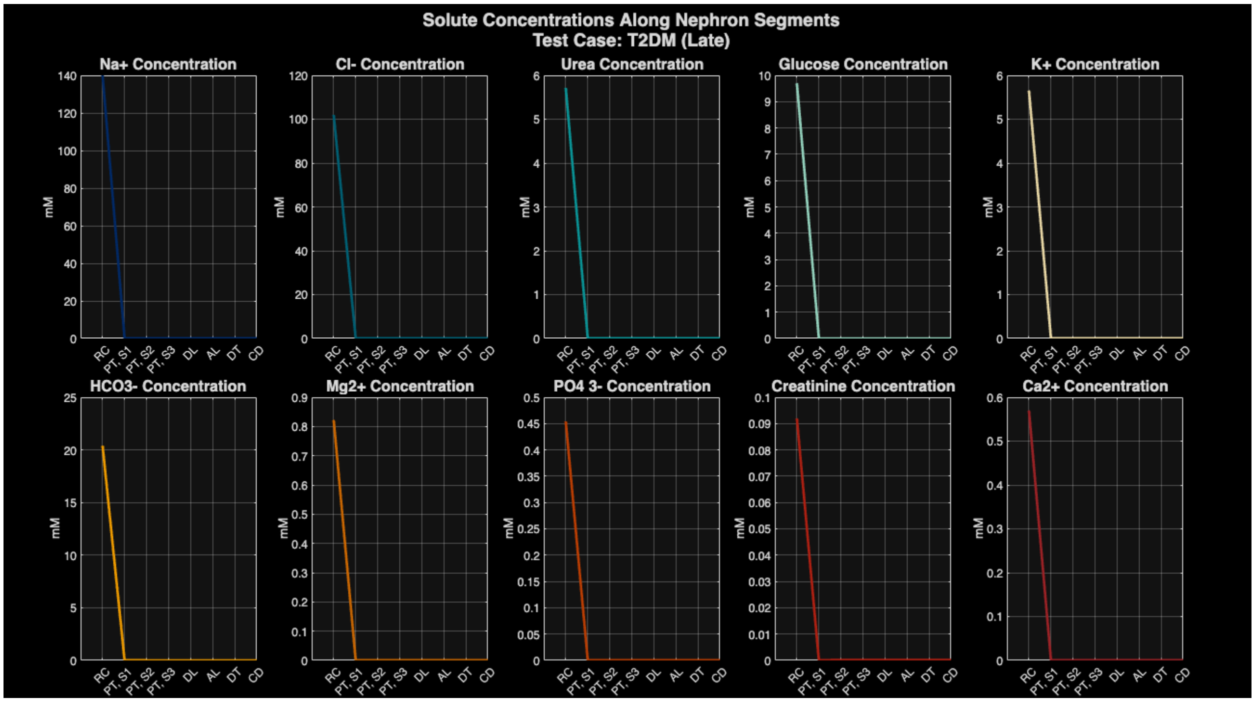

Molar Flow Rates Along Nephron Segments
Test Case: Healthy
Na+ Flow
Cl- Flow
Urea Flow
Glucose Flow
K+ Flow
HCO3- Flow
Mg2+ Flow
PO4 3- Flow
Creatinine Flow
Ca2+ Flow
mmol/min
RC
PT, S1
PT, S2
PT, S3
DL
AL
DT
CD

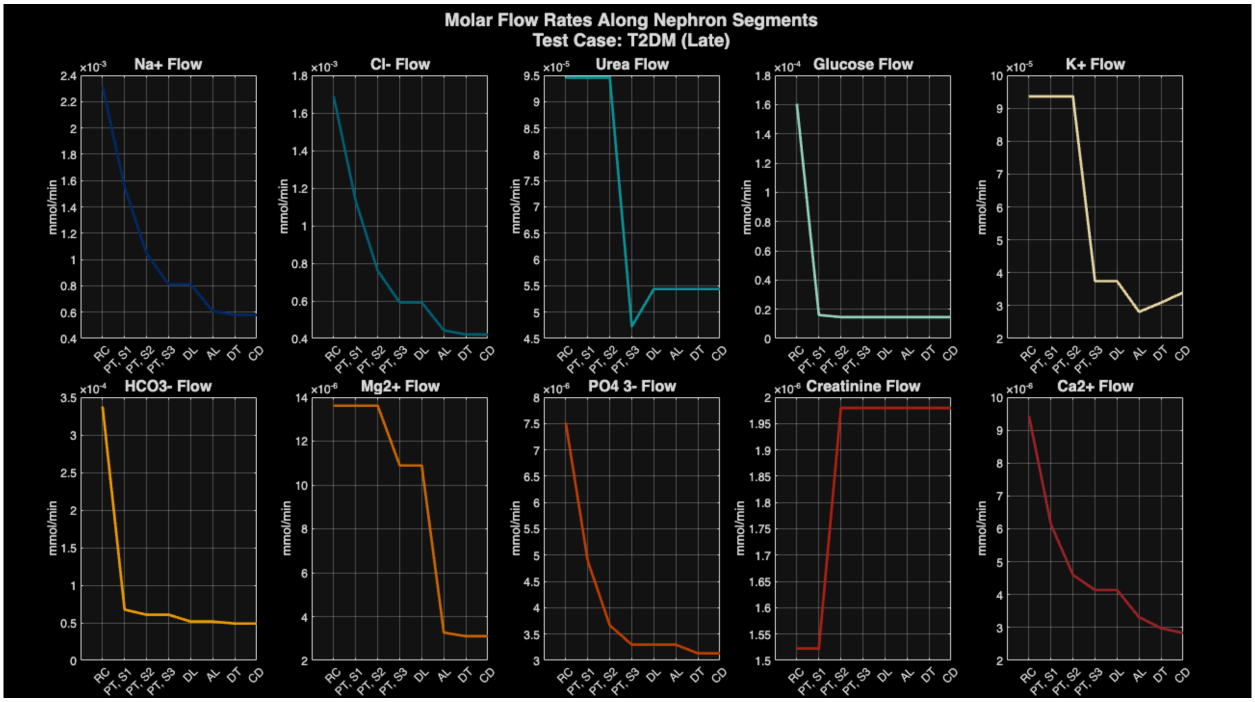

Solute Concentrations Along Nephron Segments
Test Case: CKD3b
Na+ Concentration
Cl- Concentration
Urea Concentration
Glucose Concentration
K+ Concentration
HCO3- Concentration
Mg2+ Concentration
PO4 3- Concentration
Creatinine Concentration
Ca2+ Concentration
mM
RC
PT, S1
PT, S2
PT, S3
DL
AL
DT
CD

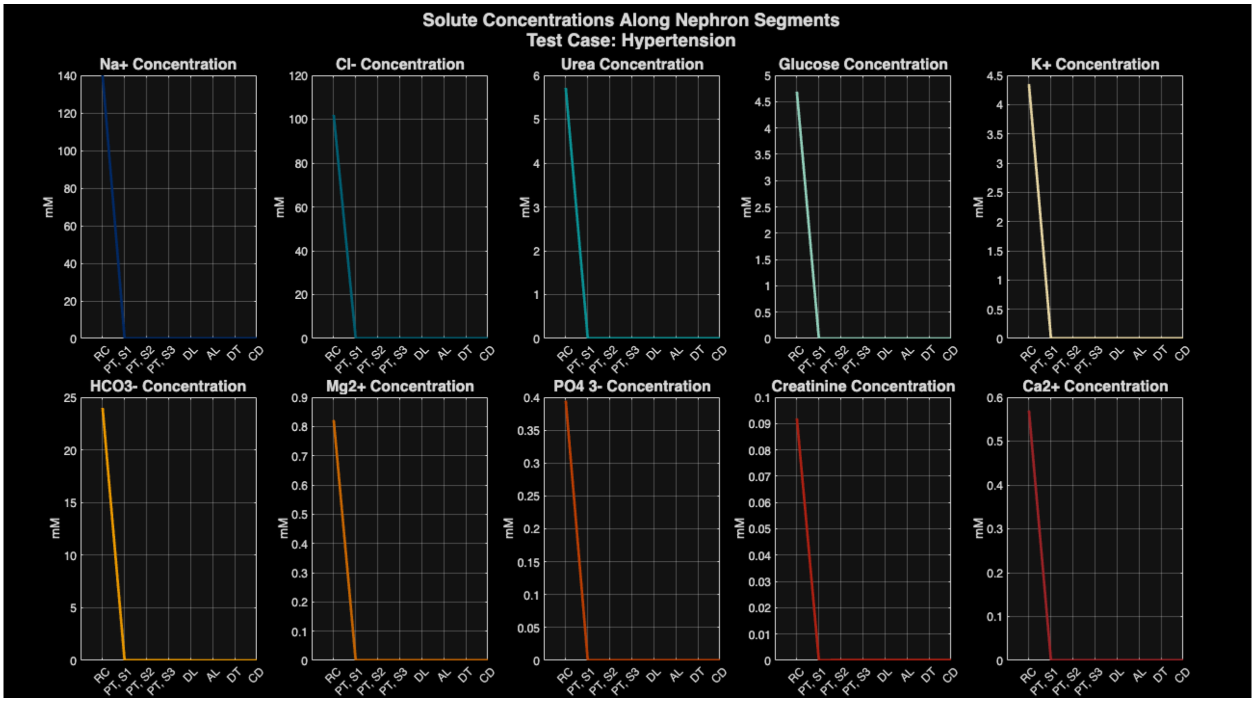

Molar Flow Rates Along Nephron Segments
Test Case: CKD3b
Na+ Flow
Cl- Flow
Urea Flow
Glucose Flow
K+ Flow
HCO3- Flow
Mg2+ Flow
PO4 3- Flow
Creatinine Flow
Ca2+ Flow
mmol/min
RC
PT, S1
PT, S2
PT, S3
DL
AL
DT
CD

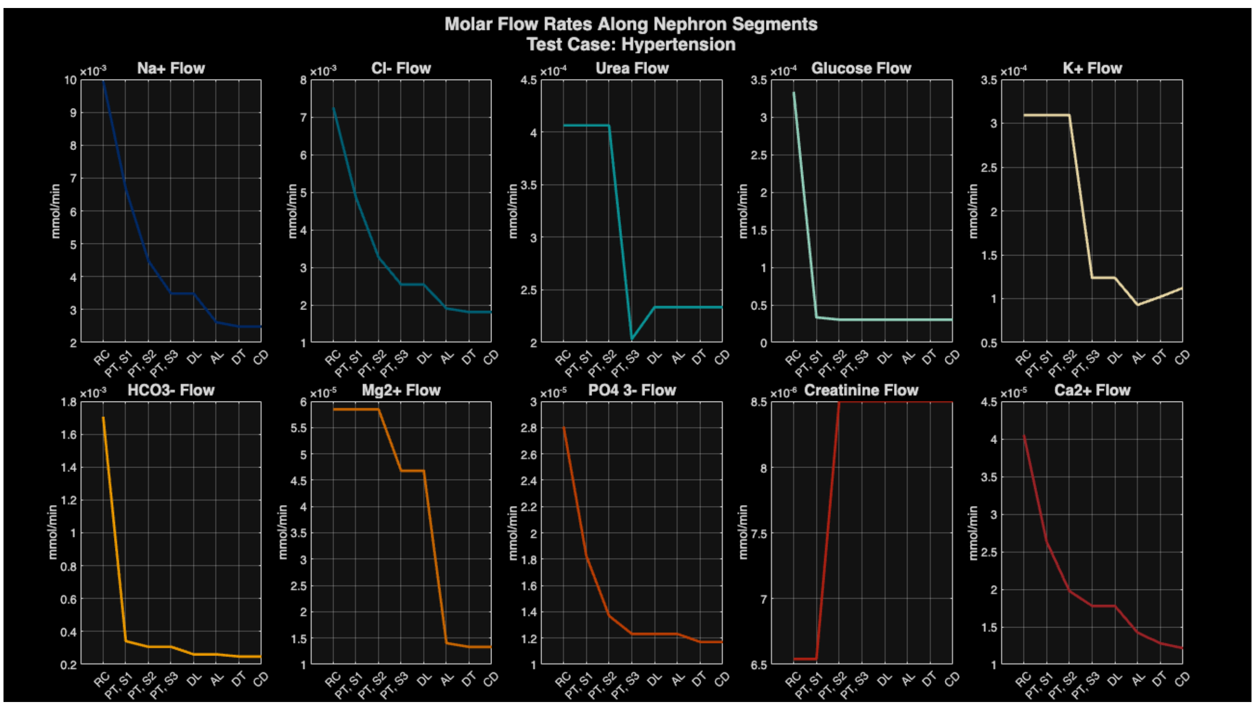

Solute Concentrations Along Nephron Segments
Test Case: T2DM (Early)
Na+ Concentration
Cl- Concentration
Urea Concentration
Glucose Concentration
K+ Concentration
HCO3- Concentration
Mg2+ Concentration
PO4 3- Concentration
Creatinine Concentration
Ca2+ Concentration
mM
RC
PT, S1
PT, S2
PT, S3
DL
AL
DT
CD

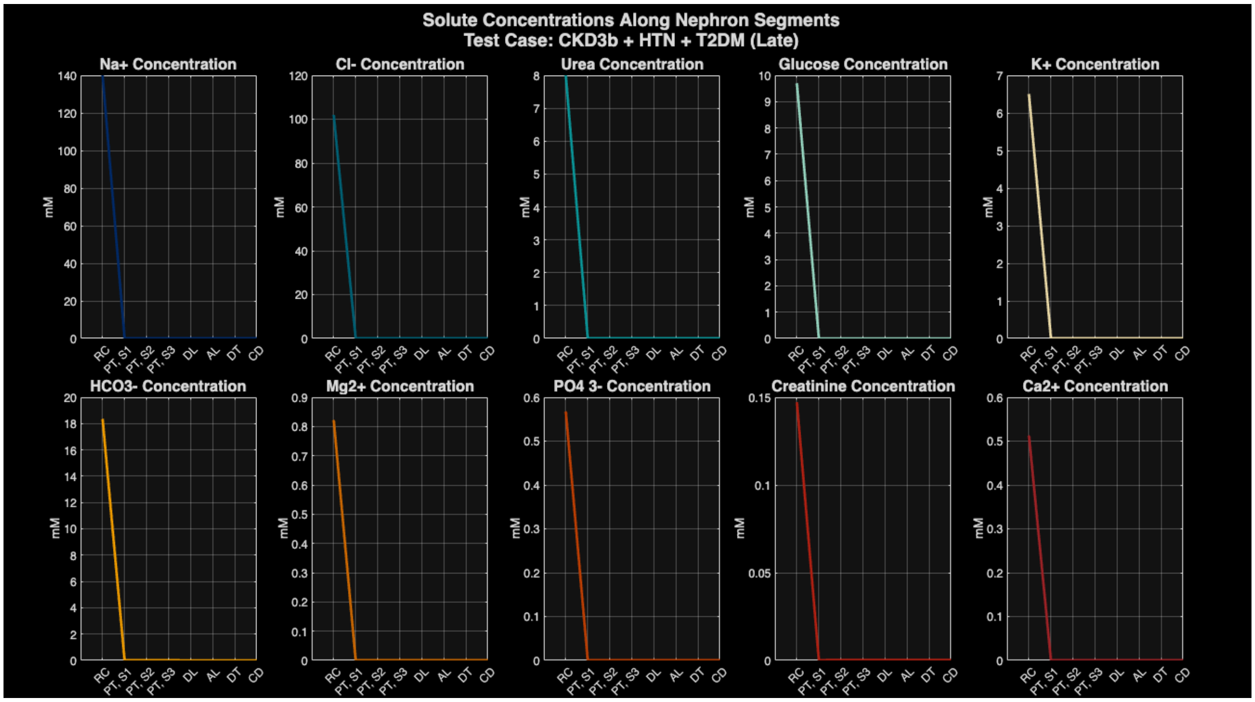

Molar Flow Rates Along Nephron Segments
Test Case: T2DM (Early)
Na+ Flow
Cl- Flow
Urea Flow
Glucose Flow
K+ Flow
HCO3- Flow
Mg2+ Flow
PO4 3- Flow
Creatinine Flow
Ca2+ Flow
mmol/min
RC
PT, S1
PT, S2
PT, S3
DL
AL
DT
CD

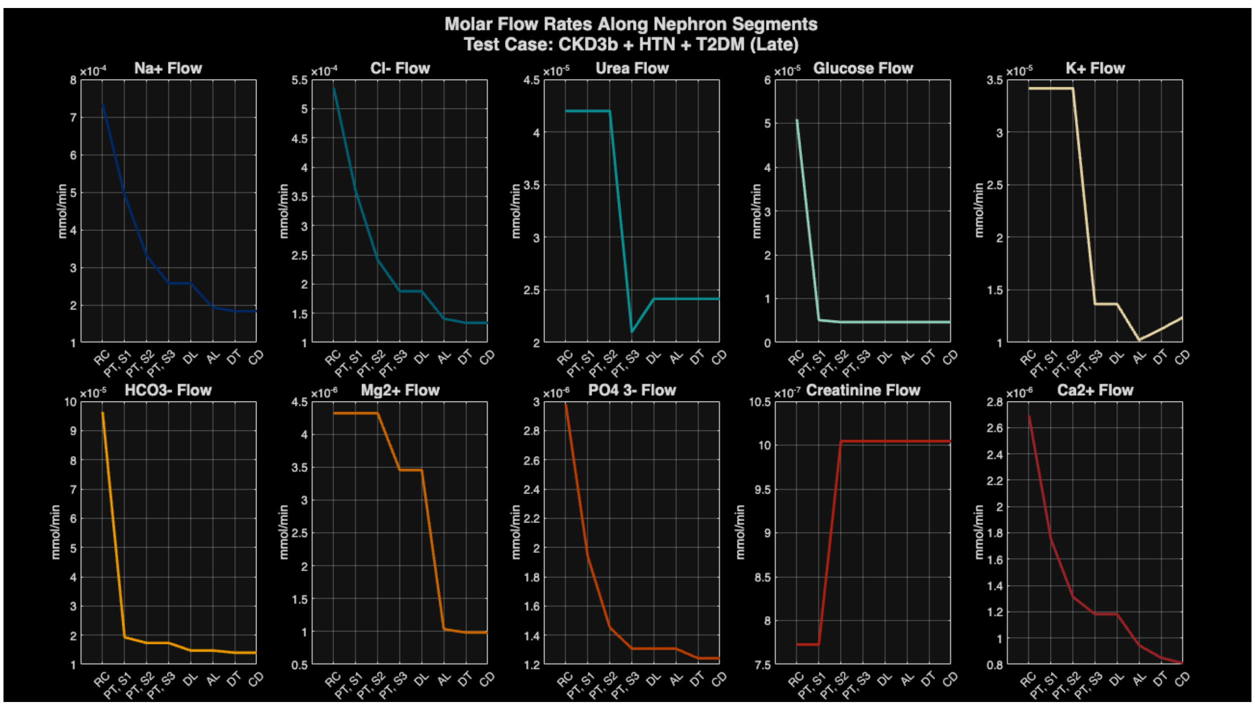

Solute Concentrations Along Nephron Segments
Test Case: T2DM (Late)
Na+ Concentration
Cl- Concentration
Urea Concentration
Glucose Concentration
K+ Concentration
HCO3- Concentration
Mg2+ Concentration
PO4 3- Concentration
Creatinine Concentration
Ca2+ Concentration
mM
RC
PT, S1
PT, S2
PT, S3
DL
AL
DT
CD


Molar Flow Rates Along Nephron Segments
Test Case: T2DM (Late)
Na+ Flow
Cl- Flow
Urea Flow
Glucose Flow
K+ Flow
HCO3- Flow
Mg2+ Flow
PO4 3- Flow
Creatinine Flow
Ca2+ Flow
mmol/min
RC
PT, S1
PT, S2
PT, S3
DL
AL
DT
CD


Solute Concentrations Along Nephron Segments
Test Case: Hypertension
Na+ Concentration
Cl- Concentration
Urea Concentration
Glucose Concentration
K+ Concentration
HCO3- Concentration
Mg2+ Concentration
PO4 3- Concentration
Creatinine Concentration
Ca2+ Concentration
mM
RC
PT, S1
PT, S2
PT, S3
DL
AL
DT
CD


Molar Flow Rates Along Nephron Segments
Test Case: Hypertension
Na+ Flow
Cl- Flow
Urea Flow
Glucose Flow
K+ Flow
HCO3- Flow
Mg2+ Flow
PO4 3- Flow
Creatinine Flow
Ca2+ Flow
mmol/min
RC
PT, S1
PT, S2
PT, S3
DL
AL
DT
CD





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